Miniature Atom Wave Interferometer for Earth and Space Remote Sensing

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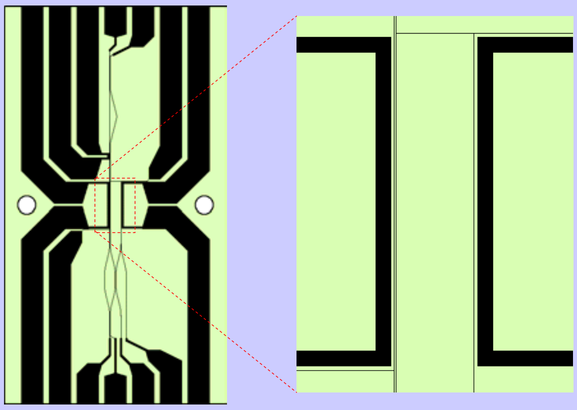
Section 335

Concept & Objectives

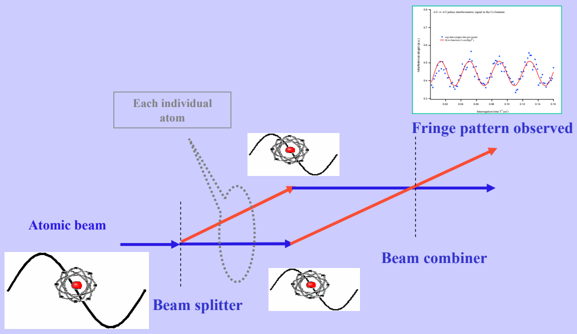
The objective of the proposed task is to develop guided atom-wave interferometer technology for compact atomic gyroscopes capable of unprecedented sensitivity of 0.1 part per billion of the Earth's rotation rate. Atom-wave interferometry (atomic interferometry) is a breakthrough technology utilizing the quantum-mechanical wave nature of matter. Atomic rotational sensors based on atomic interferometers can be extremely sensitive because of the large mass energy of the interfering particles.

Programmatic Relevance

Precise rotation sensing capabilities are of significant interest to NASA's Earth Science (Code Y) and Space Science (Code S) missions. The most commonly known applications of precision rotation sensors are in inertial guidance and navigation. JPL missions benefiting from this capability include Terrestrial Planet Finder (TPF), and other missions requiring precision pointing.

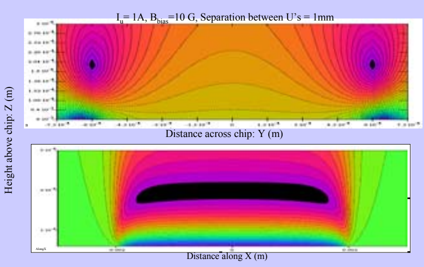


Layout of our atom chip waveguide. This device is being manufactured by Metrigraphics Inc. It features 10 micron wide hyflex gold wires. The substrate is aluminum oxide. The atom chip incorporates a number of novel features, including an "atom FET (field-effect transistor)." This chip will allow us to demonstrate several key technologies, including beam splitting and combining of atoms in waveguides

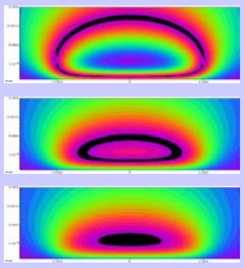


Atomic interferometer concept. Atomic matter waves are divided by a beam-splitter, separated, and recombined, allowing interference to be observed at the output.

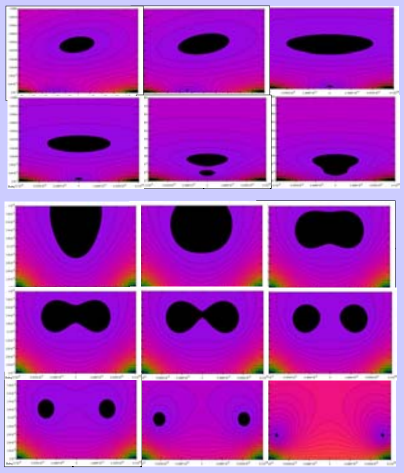
Modeling waveguide performance:



Magnetic field contour plot ($|B_u+B_{bias}|$)of a double-U micro-trap with transverse bias field.



Field lines (along x-axis (y = 0))



Calculation of magnetic potentials as atoms are loaded from magnetic transfer trap into double-U trap. These simulations allow us to verify that we will be able to load the waveguides successfully. They have also allowed us to consider novel interferometers based solely on the transfer of atoms from one trap to two, and back.

Potential of the magnetic field above a two-wire, Y shaped, beam splitter. This calculation allows us to determine the optimal splitting angle for our waveguide.

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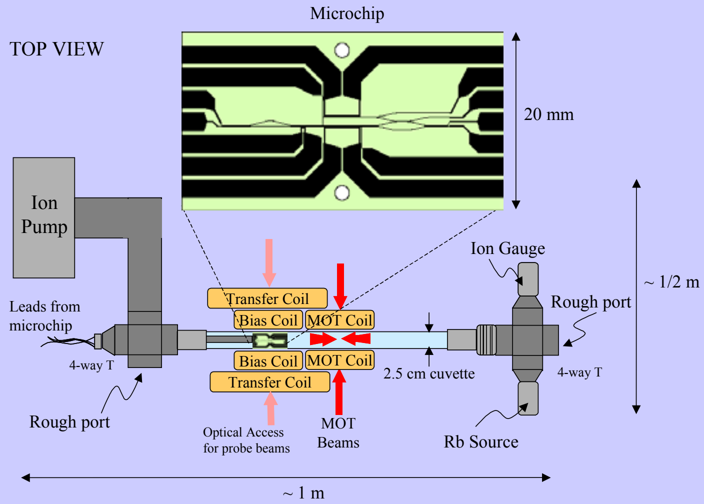
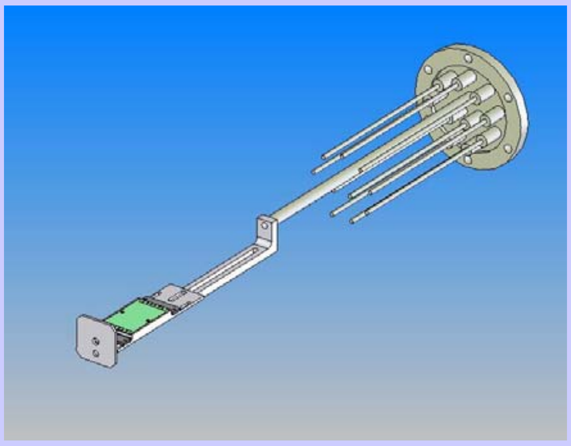
Implementing the atom-chip:

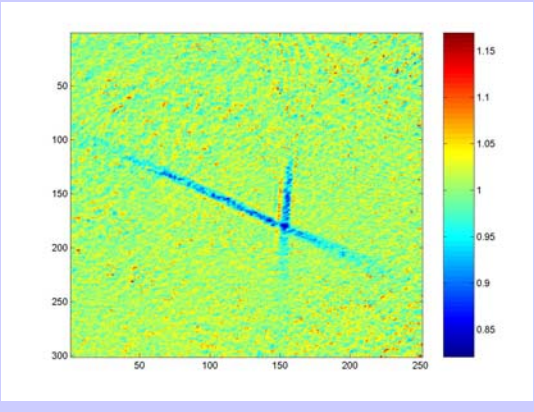


Cartoon of the vacuum apparatus, showing the position of magnetic coils needed to collect atoms and transfer atoms onto the atom chip.



Mounting hardware for the atom chip. This image shows the hardware needed to mount the atom chip to a UHV feedthrough.

Future directions:



Absorption image of atoms trapped in a crossed-beam optical trap. We are investigating this technology as a possible way to load atoms into our atom chip. It has the potential for loading significantly colder and denser samples of atoms into the waveguide than is possible with the magnetic trapping techniques used previously, and opens the way for loading coherent, Bose-condensed atomic samples.